ARJUNA

JEE

LECTURE - 10

Atomic structure

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Q. Kinetic energy of revolving particle is x joule. Than calculate de-Broglie's wavelength

A h/x ✗ 40-50 Sec

B h/(xm)2 ✗

C h/2x ✗

D NONE OF THESE ✓

$K.E = x$ Joule

$$\lambda = \frac{h}{\sqrt{2m \times K.E.}} = \frac{h}{\sqrt{2mx}} = \frac{h}{(2mx)^{\frac{1}{2}}}$$

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Q. The shortest wavelength of H atom in the Lyman series is λ_1. The longest wavelength in the Balmar series of He is

[04 September (Evening) 2020]

A $\frac{5\lambda_1}{9}$ ✓

50 sec

B $\frac{36\lambda_1}{5}$

C $\frac{27\lambda_1}{5}$

D $\frac{9\lambda_1}{5}$

$\frac{1}{\lambda_1} = R(1)^2\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right) = R$

$\boxed{\frac{1}{\lambda_1} = R}$ — (I)

$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

(I) $H \rightarrow Z = 1$

Lyman $\rightarrow n_1 = 1, n_2 = \infty$

$Z = 2, n_1 = 2, n_2 = 3$ $\left(\lambda \propto \frac{1}{\Delta E}\right)$

$\frac{1}{\lambda} = R(2)^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = 4R \times \frac{5}{4 \times 9} = \frac{5R}{9}$ — (II)

$\frac{(I)}{(II)} = \frac{\frac{1}{\lambda}}{\frac{1}{\lambda_1}} = \frac{R}{\frac{5R}{9}} \Rightarrow \frac{\lambda_1}{\lambda} = \frac{9}{5}$, $\lambda = \frac{5\lambda_1}{9}$

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Uncertainty principle

- According to this principle, "it is impossible to measure simulateously the position and momentum of a microscopic particle with absolute accuracy". If one of them is measured with greater accuracy, the other becomes less accurate.

applicable

e^-, p^+, n^0, α-particle

-

e^- = Energy absorb

** $$\Delta x \times \Delta p \geq \frac{h}{4\pi}$$

Where → Δx = uncertainty in position

Δp = uncertainty in momentum

min. uncertainty → $\Delta x \times \Delta p = \frac{h}{4\pi}$

$\Delta x \to 0$, $\Delta p \to \infty$

$$\Delta p = m\Delta v$$

$$\Delta x \times \Delta p \geq \frac{h}{4\pi}$$

$$\Delta x \times m\Delta v \geq \frac{h}{4\pi}$$

*** $$\boxed{\Delta x \times \Delta v \geq \frac{h}{4\pi m}}$$

→ Prove that uncertainty principle applicable for microscopic particles

Q → particle (m) = 10^{-9} kg

$$\Delta x \times \Delta v \geq \frac{h}{4\pi m}$$

$$\Delta x \times \Delta v = \frac{6.6 \times 10^{-34}}{4 \times 3.14 \times 10^{-9}}$$

$$\boxed{\Delta x \times \Delta v = 5.24 \times 10^{-26}}$$

total uncertainty is approx neglect value

Q particle (m) = 10^{-31} kg

$$\Delta x \times \Delta v \geq \frac{h}{4\pi m}$$

$$\Delta x \times \Delta v = \frac{6.6 \times 10^{-34}}{4 \times 3.14 \times 10^{-31}}$$

$$\Delta x \times \Delta v = 5.24 \times 10^{-4}$$

this uncertainty is not neglected

Q Select the species (particle), follows uncertainty principle.

(a) 1 Kg particle ✗

(b) Ball ✗

(c) e^- ✓

(d) these of these

Q Which particle does not follows uncertainty principle (more than one Correct Ans)

(a) 10^{-2} gram particle ✓

a, b, c

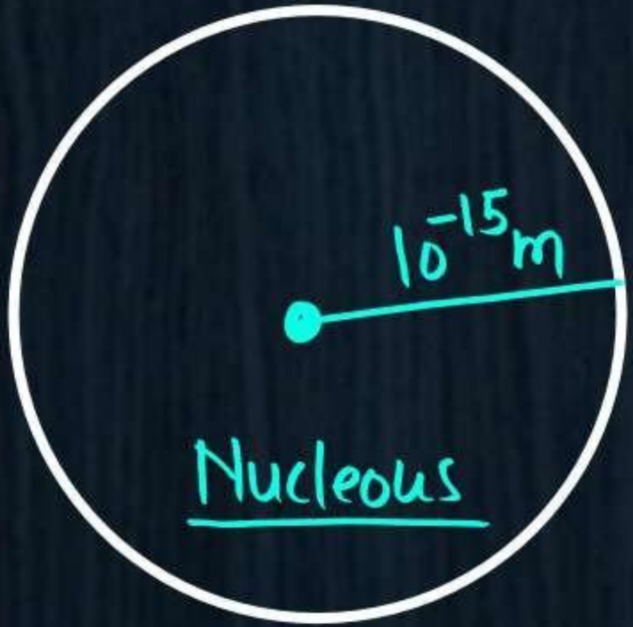
(b) 1 gram ✓

(c) 10 gram ✓

(d) 10^{-27} kg

Q Can an electron remain inside the nucleous (school me puchhete hai)

suppose → e^- present in nucleous ($\Delta x = 10^{-15}$)



$$\Delta x \times \Delta v \geq \frac{h}{4\pi m}$$

$$\Delta v \geq \frac{h}{4\pi m \Delta x}$$

$$\Delta v = \frac{6.6 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 10^{-15}} = 5.77 \times 10^{10} \frac{m}{sec}$$

↑ this uncertainty value is not possible

Reason = Δv is greater than speed of light

$C = 3 \times 10^{8} \frac{m}{sec}$

It means value of Δx also not possible ⇒ e^- can not exist inside nucleous

Q22. Given, the mass of electron is 9.11×10^{-31} kg, Planck's constant is 6.626×10^{-34} Js, the uncertainty involved in the measurement of velocity within a distance of 0.1Å is

(a) $5.79 \times 10^{6}\ ms^{-1}$

(b) $5.79 \times 10^{7}\ ms^{-1}$

(c) $5.79 \times 10^{8}\ ms^{-1}$

(d) $5.79 \times 10^{5}\ ms^{-1}$

$$\Delta x \times \Delta v = \frac{h}{4\pi m}$$

$$(0.1 \times 10^{-10}) \times \Delta v = \frac{6.6 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31}\ kg}$$

$$= 5.77 \times 10^{6}\ m/sec$$

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Q19. If uncertainty in position and momentum are equal, then uncertainty in velocity is

(a) $\frac{1}{2m}\sqrt{\frac{h}{\pi}}$

(b) $\sqrt{\frac{h}{2\pi}}$

(c) $\frac{1}{m}\sqrt{\frac{h}{\pi}}$

(d) $\sqrt{\frac{h}{\pi}}$

$\Delta x = \Delta p$

$\Delta v = ?$

$\Delta x \times \Delta p = \frac{h}{4\pi}$

$\Delta p \times \Delta p = \frac{h}{4\pi}$

$(m\Delta v)^2 = \frac{h}{4\pi}$

$\Delta v^2 = \frac{h}{4\pi m^2}$

$\Delta v = \sqrt{\frac{h}{4\pi m^2}} = \frac{1}{2m}\sqrt{\frac{h}{\pi}}$

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Schrodinger Equation (Wave model of Atom)

❖ Schrodinger equation is central equation of wave mechanics according to following equation

→ $\bar{e}$ → suppose ⇒ wave hai

→ $\bar{e}$ → Represent in term of wave function (ψ)

$$\psi = A \sin \omega t$$

solve above Eq.

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Schrodinger Equation

$$\frac{\partial^2\psi}{\partial x^2}+\frac{\partial^2\psi}{\partial y^2}+\frac{\partial^2\psi}{\partial z^2}+\frac{8\pi^2 m}{h^2}(E-V)\psi=0$$

ψ = Wave function = f(x, y, z)

E = Total energy of particle

V = Potential energy of particle.

- A solution to schrodinger equation leads to infinite solution.
- Most of the solution are not realistic (or acceptable). Only few solution can be accepted.

$y = 4x^2$

$\frac{dy}{dx} = 4\times 2x$

$\frac{d^2y}{dx^2} = 4\times 2\times 1 = 8$

$x^2 - 4 = 0$

$x^2 = 4$

$x = \pm 2$ — $+2 \Rightarrow 4$, $-2 \Rightarrow 4$

solution of wave Equation → Quantum Number

Principal Quantum Number (n)

→ P. Q. number → represented by 'n'

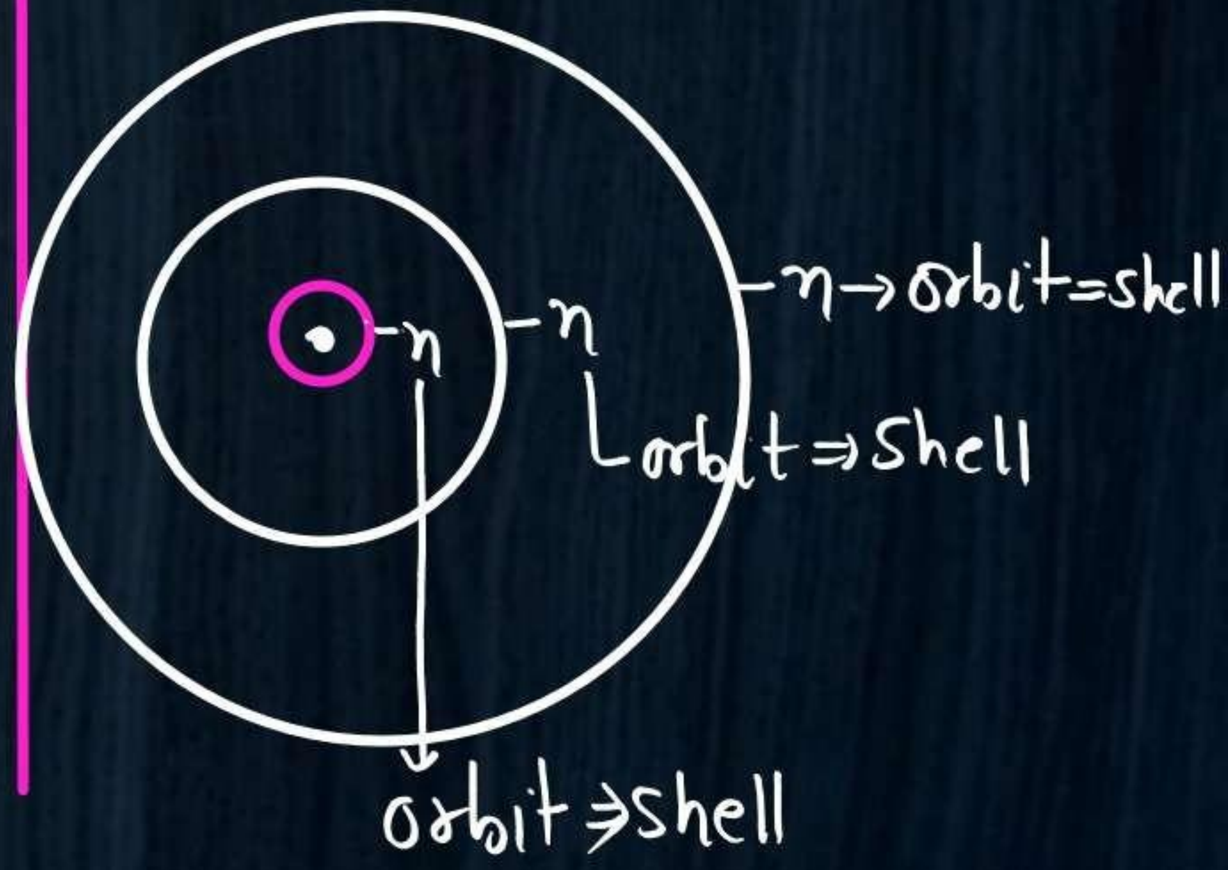
$n = 1, 2, 3, 4, 5$ - - - - -

$n \neq 0$

$n \neq$ fraction

$n \Rightarrow$ Shell

principal Quantum No Ki value similar hai Bohr's orbit No. ke



→ Represent → size of atom

→ total energy of electron

$n = 1, 2, 3, 4, 5, 6 - - - -$

(2) Azimuthal Quantum Number (l) or Angular Quantum Number

→ Azimuthal Quantum No. represent → orientation of subshell

→ Value of l → 0 to $n-1$

→ l ⇒ subshell → (shell ke under subshell hote hai)

Ex → $n = 2$	$n = 3$
$l = 0, 1$	$l = 0, 1, 2$

$n = 2$	$n = 3$
$l = 0, 1$	$l = 0, 1, 2$

$\Rightarrow$ No. of subshell = value of n in any shell

Q How many subshell in 5th shell

(a) 1

(b) 2

(c) 3

✓ (d) 5

$n = 5$

No. of total subshell in 5th shell = 5

$n = 5$

$l \rightarrow 0$ to $n-1 \Rightarrow 0, 1, 2, 3, 4$

Q Select the possible value of subshell for 5^{th} shell

(a) 6 → ✗

(b) 5 → ✗

(c) 3.5 → ✗

(d) ✓ 1

$n = 5$

$l \rightarrow 0 \text{ to } (n-1) \rightarrow 0, 1, 2, 3, 4$

l (subshell)	
0	→ s-subshell
1	→ p-subshell
2	→ d-subshell
3	→ f-subshell
4	→ g-subshell
5	→ h-subshell
6	→ i-subshell
7	⋮
⋮	

Q select the subshell, which not present in 2nd shell

(a) s-subshell

(b) p-subshell

(c) d-subshell ✓

(d) All

$n = 2$

$l \to 0$ to $n-1 \Rightarrow 0, 1$

0 → s-subshell

1 → p-subshell

Shell	Subshell (l)	
	$l \to 0$ to $(n-1)$	
$n=1$ (1st shell) →	$l=0$ →	s-subshell
$n=2$ (2nd shell) →	$l=0, 1$ →	s-subshell ($l=0$) p-subshell ($l=1$)
$n=3$ (3rd shell) →	$l=0, 1, 2$ →	$l=0 \to$ s-subshell $l=1 \to$ p-subshell $l=2 \to$ d-subshell
$n=4$ (4th shell) →	$l=0, 1, 2, 3$ →	$l=0 \to$ s-subshell $l=1 \to$ p- " " " $l=2 \to$ d- " " " $l=3 \to$ f-subshell

Q → select Correct match

List-1		List-2	
(a)	$l = 0$	(p)	f-subshell
(b)	$l = 1$	(q)	p-subshell
(c)	$l = 3$	(r)	s-subshell
(d)	$l = 2$	(s)	d-subshell

a → r

b → q

c → p

d → s

(3) Magnetic Quantum Number (m or m_s or m_l)

→ value of m → $-l$ to $+l$ or $+l$ to $-l$

Ex ⇒ $l = 1$ → $m = \begin{cases} -1 \\ 0 \\ +1 \end{cases}$

p-subshell

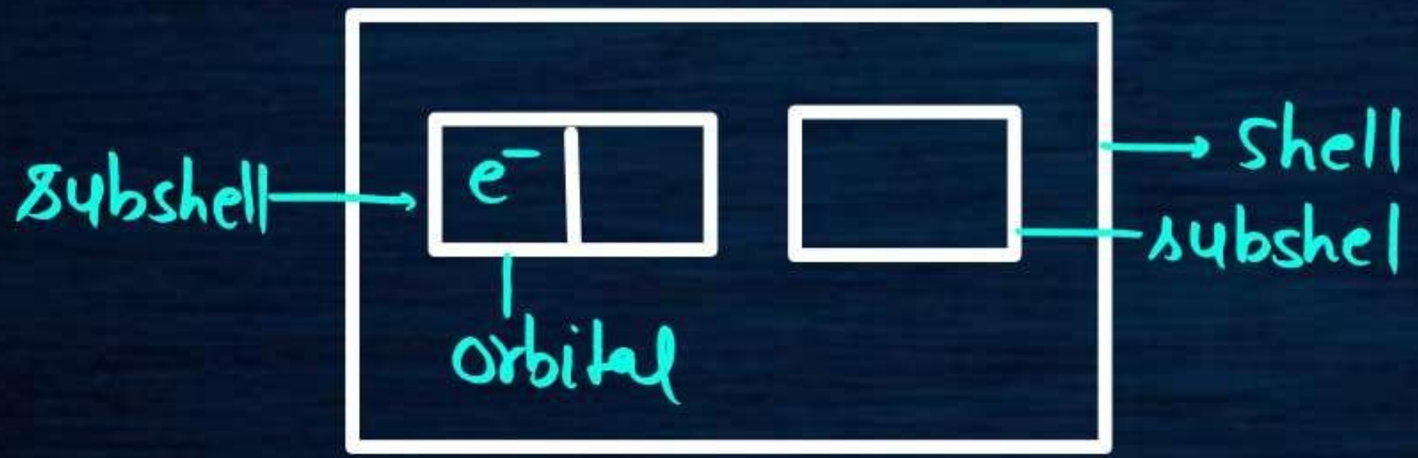
→ subshell Ke under → orbital (m)

m = orbital (□)

(m)

❖ Atomic Orbital : This is a three dimensional space around the nucleus within which the probability of finding the electron is maximum. (95% approx)

→ e^- present inside the orbital



$-l$ to $+l$

$l = 0 \longrightarrow m = 0$ — s-orbital

(s-subshell) → 1-orbital

$l = 1 \longrightarrow m = \begin{cases} -1 \longrightarrow p_x | p_y \\ 0 \longrightarrow p_z \\ +1 \longrightarrow p_x | p_y \end{cases}$

(p-subshell) → 3 orbital

$p_x | p_y = \pm 1$

$p_x \quad p_y \quad p_z$ → equal energy of p_x, p_y & p_z

$p_z \downarrow 0$

$l = 2$ → $-l$ to $+l$

- -2
- -1
- 0 → d_{z^2}
- $+1$
- $+2$

$d_{xy}, d_{yz} = \pm 1$

$d_{x^2-y^2}, d_{xz} = \pm 2$

d-subshell = 5 orbital

→ equal Energy

$d_{xy}, d_{yz}, d_{xz}, d_{x^2-y^2}, d_{z^2}$

<u>Note</u> → total No. of orbital in any subshell = $2l+1$

subshell	formula = $2l+1$ total orbit in any subshell
s-subshell ($l=0$) →	$2\times0+1=1$
p-subshell ($l=1$) →	$2\times1+1=3$
d-subshell ($l=2$) →	$2\times2+1=5$
f-subshell ($l=3$) →	$2\times3+1=7$
g-subshell ($l=4$) →	$2\times4+1=9$

Q→ How many orbitals in d-subshell

(a) 2

(b) 3

(c) 7

✓ (d) 5

No. of orbital $= 2l+1$

$= 2\times 2+1$

$= 5$

Difference

Orbit	Orbital
→ term = Bohr's theory	→ Schrodinger wave Eq.
→ Energy level or circular path	→ Quantum Number (m)
→ $n = 1, 2, 3, 4, ---$	$m = 1, 2, -1, -2, 0$ ($-l$ to $+l$)
→ less probability to finding of e^-	→ 95% approx → finding of e^- probability

Home work

DPP 07

Thank - You